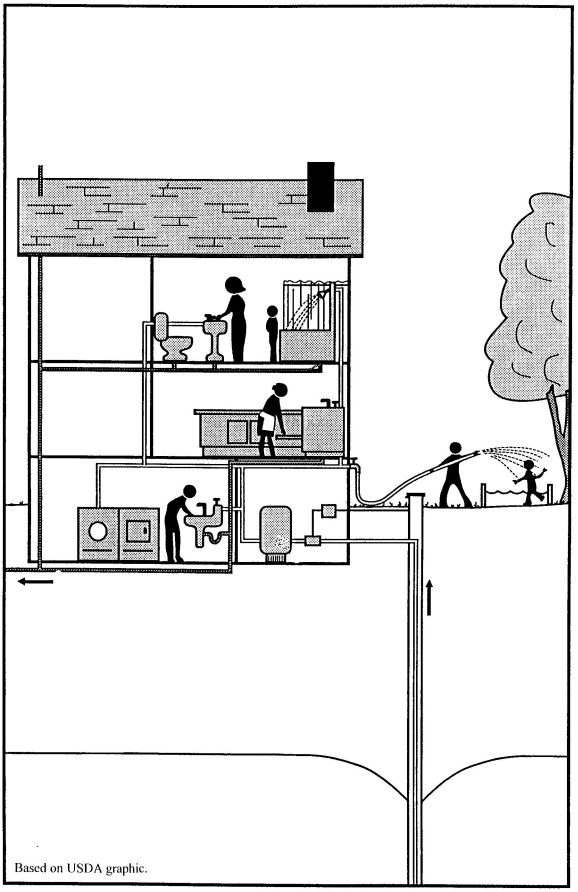
America's Priceless Ground Water Resource



American Ground Water Trust
Consumer Awareness Information Pamphlet # 1

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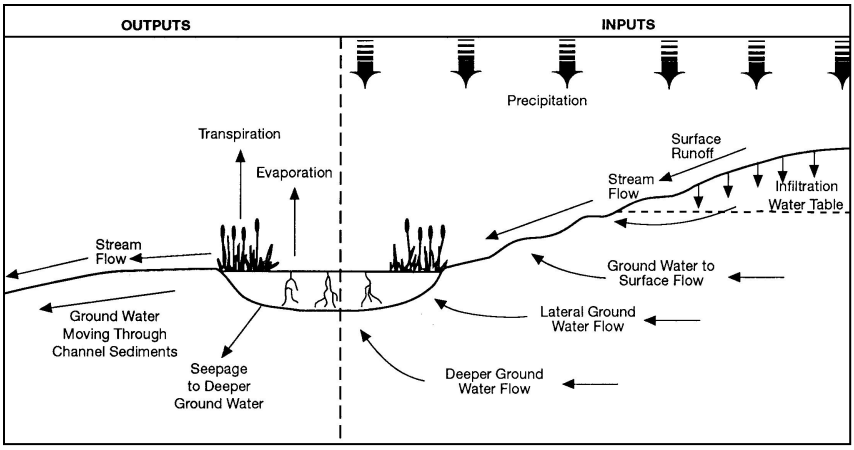


The Local Hydrologic System

NATURE'S WATER CYCLE

Hidden beneath the land surface, in almost every part of the United States, is pure wholesome water that scientists call "ground water." Ground water is simply the water that fills cracks and other openings in beds of rock and sand. Rain and snow that soaks into the soil may be used by plants or may evaporate back into the atmosphere. Some will trickle downward to the "water table." This is the water level in the ground water reservoir. From there, it begins to travel slowly through the saturated rocks or sediments until it reappears in some lowland area, which may be along the shore of a lake, a river, a wetland, or the sea. Springs are places where ground water appears at the surface in a visible flow. Saturated layers of rock that contain ground water are called aquifers.

The movement of rain water into the soil, through the earth, and finally into rivers and the sea, is all part of a never-ending water cycle that has been going on since the dawn of time. A large part of the water in rivers is ground water that has slowly escaped from the rocks and sediments along valley floors, which is why most rivers continue to flow even after long periods of little

or no rainfall. The sun, which evaporates fresh water from lakes and oceans and then sends it back to earth again during rain and snow storms, is the source of energy for this huge water system.

MISCONCEPTIONS CONCERNING GROUND WATER

The movement of ground water is governed by the laws of physics. Ground water is neither mysterious nor occult; it does not occur in underground lakes or rivers, and spring water is not synonymous with purity. Nevertheless, there are widely held beliefs to the contrary. These and other misconceptions of the nature and behavior of ground water are examined in this pamphlet.

Misconception	Ground water occurs in underground lakes and rivers
Reality	Ground water bears little resemblance to surface water

The mistaken concept that all ground water occurs in underground lakes and rivers is based upon conditions that do sometimes occur in areas where limestones form the major aquifers. In some areas of limestone, water may flow in underground openings, such as caves and solution channels. In one sense, ground water moving in these large openings, which are relatively rare, resemble streams. In the vast majority of cases, however, ground water occurs in rock formations that have small interconnected openings (permeable material) for the water to pass through. Aquifers (water-bearing deposits), may be small and localized or connected for hundreds of square miles.

Along many river valleys, the flood plain deposits consist of permeable sand and gravel. In such cases, the ground water may flow generally in the same direction as the surface stream. The flow characteristics of the ground water in the stream-side deposits is very different from flow in the surface stream. This large volume of slowly

moving ground water adjacent to the stream may even flow in a direction different from the regional bedrock ground water flow in nearby areas.

During the last Ice Age, when glaciers advanced across the northern part of the United States, many of the stream channels were filled and the streams were forced to develop other courses. The sediments of these now-buried river valleys may contain great quantities of ground water and the aquifer's shape may be long and sinuous, but cannot be likened to an underground river.

Misconception	Water rushes so rapidly underground that its presence can be detected by listening
Reality	In most cases ground water flows only a few inches per day

Some people believe they can detect the presence of large quantities of water underground merely by placing an ear to the earth and listening for the sound of rushing water. This is not possible because ground water moves very slowly through the earth, in most cases only a few inches per day. Although it may flow rapidly in limestone terrain characterized by large openings, such as caves, such conditions are rare. Ground water velocity is of particular importance in water-pollution problems. Because of its slow rate of movement, an area once polluted may remain unusable for years. It is primarily for this reason that disposal of wastes on and in the ground is closely regulated.

The 1981 Superfund legislation that established the principle of 'polluter pays' has done much to encourage industry and landfill managers to avoid irresponsible disposal of toxic wastes.

Misconception	Ground water migrates thousands of miles
Reality	Most ground water is replaced nearby

Much of the water in a ground water reservoir infiltrates within a radius of a few miles of where it is found. It has not traveled in the ground for thousands or even hundreds of miles. There are no underground rivers transporting great volumes of pure water from Canada to Kansas, or from Michigan to Florida. However, there are some large aquifers, such as the Ogallala in the High Plains, that do extend for hundreds of miles.

Misconception	There is no relationship between ground water and surface water
Reality	Ground water provides much of the flow of streams; most lakes and swamps are windows in the water table

It is commonly believed that ground water and surface water are separate systems. Consider, however, a stream in late summer. Although it may not have rained for several days or possibly even weeks, there may still be a considerable flow in the stream. Obviously, this water could not have been derived from the surface runoff of rainfall. The stream flow represents water that has flowed from the ground into the stream channel. In other words, the low flow of a stream may be derived entirely from ground water discharge. Forty percent of the flow of all U.S. rivers combined (including the Mississippi !) originated as ground water. In addition, wells located near a stream may cause water to flow from the stream to the wells, thus reducing the stream flow.

Misconception	Ground water is not important for water supply
Reality	The amount of ground water dwarfs our present surface supply. 53% of America's drinking water comes from wells

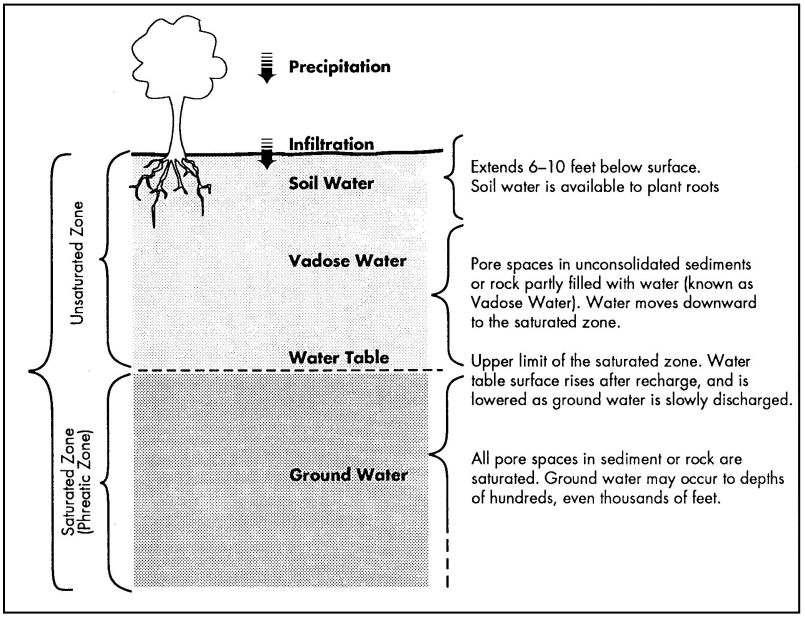
Ground water is commonly considered an insignificant water resource. The fact is that in the U.S. the quantity of water is underground storage at any moment is 20 to 30 times greater than the amount in all the lakes, streams, and rivers combined. At the same time, ground water is usually cool and clear, of a nearly constant temperature, free of sediment, and of generally good quality. The major feature of ground water is its widespread occurrence. It commonly provides a reliable and economical water supply for many kinds of activities for which surface water supplies would be uneconomical or not feasible. There are over 15 million private (independent) wells that supply water to 44 million people.

Approximately 6,000 new water wells are constructed each week. Approximately 37% of all public supplies and about 96% of all rural domestic supplies are derived from wells. About 34% of the water used for agriculture is ground water. Were it not for huge ground water reservoirs, many irrigation systems in the arid and semi-arid regions of the U.S. could not continue. Agriculture and industry alike utilize ground water because in most cases it is available at the point of use and does not require long distance pipelines.

Misconception	Ground water removed is never returned
Reality	Ground water is a renewable resource

In most parts of the country, water removed from the ground is constantly replaced. Thus, ground water is a renewable resource, although in some places the rate of replenishment is very slow. In some arid and semi-arid regions, a slow rate of replenishment is far exceeded by the rate of ground water pumping; this is called ground water mining.

Areas where water seeps into the ground are called recharge areas; they include virtually the entire land surface, although recharge rates vary greatly. Some types of soil accept much more rapidly than others. For example, the rate of infiltration (the rate at which water seeps into the ground) through sandy soil will be much greater than through



Subsurface Water

a heavy clay soil. Relatively high rates of recharge (infiltration) may occur in sandy or gravelly areas and along river flood plains where the water table has been lowered by pumping. In arid areas, aquifer recharge may only occur when flash floods produce enough water to soak into the ground through stream beds and adjacent flood areas.

Areas with high rates of recharge should be carefully managed for two major reasons. First, adequate time is needed to allow replenishment of underlying ground water reservoirs (aquifers) and, second, water-soluble waste products stored in these areas may infiltrate and pollute the underground supply. Consequently, areas of high recharge must be properly managed in order to maintain and protect the quantity and quality of water in storage.

Misconception	Ground water is mysterious and occult
Reality	Natural laws control the occurrence and movement of ground water

Before the development of scientific techniques of ground water hydrology, the natural laws controlling water movement were unknown. This led to the idea, preserved in case law, that the occurrence and movement of water in the ground is mysterious and occult and that the principles of its behavior cannot be known. In fact, using well-established natural laws of physics and thermodynamics and the relevant hydrologic data, the quantity and quality of ground water can be predicted.

THE ABUNDANCE OF WATER IN THE GROUND

Ground water is by far our largest water resource; it is estimated that more than 95% of the water that occurs in America at any one time is in rock fractures and porous beds of rock and sand. In many parts of the U.S., such as the broad plains along the Atlantic Ocean and the Gulf of Mexico, incredibly large quantities of ground water can be found. For example, there is one-fifth as much fresh water in Florida's rock formations as there is in all of the Great Lakes.

Today, when many rivers and lakes have been tapped for water supplies to their full capacity, or have been polluted to a dangerous degree, people are turning more and more to the potable ground water that can be found almost everywhere. A water well system is usually easier and more economical to operate than almost any other water supply system. In the old days, ground water was thought of only as a source for household use, but today it is tapped for large supplies by municipalities, industries, homes, and irrigation systems all across the nation.

The amount of ground water that can safely be pumped year after year depends mainly on two factors: (1) the quantity of water in the underground formations and (2) the climatic and geologic conditions that affect replenishment of the ground water source. Water already contained in a natural ground water reservoir has been accumulating over years, or even centuries, and is a largely untapped reserve water supply to carry through periods of little or no rainfall.

If the amount of water taken from wells in a certain locality is less than the long-term replenishment from rainfall, pumping may be continued indefinitely without causing any harmful effects. However, if pumpage is greater than the replenishment, too much demand will be made on the ground water already stored. In such cases, continued pumping may slowly lower the water table. Thus, despite its abundance in almost every part of the country, ground water is not an inexhaustible resource. Like all natural resources, it must be conserved and properly managed to ensure its availability in the future. It is like a bank account. How much do you have in savings, and how much/and how often are payments made into the account? You need to know this before planning your budget!

Conservation of a natural resource means wise use of the resource. For a renewable resource such as ground water, we need to use and manage it on the basis of the natural laws that govern its occurrence and replenishment.

One way in which we can maintain or even increase our supply of usable water is by removing polluting wastes from used water before disposing of it. Where water quality is excessively damaged, it cannot be used without extensive treatment. Conservation works in the present with an eye to the future.

THE HIGH QUALITY OF GROUND WATER

A high level of purity is a principal reason why ground water is an ideal water supply. The quality of ground water is determined mainly by the character of the earth materials through which the water has seeped and the rocks where it occurs. Most ground water contains some minerals dissolved from these materials.

The dissolved minerals are rarely harmful to health and may give the water a pleasant taste. Moreover, since the underground formations act as natural filters to screen out pollution, the degree of purity of ground water far exceeds that of surface water. Bodies of surface sources (rivers, lakes, and reservoirs) are readily pollutable

because they receive surface drainage without natural filtration.

Ground water in deep sand or rock layers often has more minerals than water in shallow deposits, because it has traveled a greater distance and has had more time to slowly dissolve those substances. “Hard” ground waters found in rock such as limestone contain large amounts of calcium. Where the earth materials include iron minerals, the ground water may also contain iron.

There are many types of water-treatment equipment available that will remove dissolved minerals from ground waters. Automatic water softeners, filters, and chlorinators, for example, can be installed on a well system to handle water flow from a trickle up to thousands of gallons per minute. Ground water contractors have access to up-to-date technical information on efficient water-treatment equipment and can assist the well owner with water-treatment problems.

The temperature of shallow ground water is normally about the same as the average annual air temperature in the vicinity. In most parts of the United States water temperatures increase about one degree Fahrenheit for each 80 to 100 feet of well depth. The water pumped from a depth of 1000 feet, for example, may be roughly 10 to 12 degrees warmer than water taken from near the land surface.

A PRICELESS RESOURCE

Of all the earth’s water resources, ground water tends to be the most abundant, the most dependable, and the purest. It can be found in almost every part of the nation, beneath almost every tract of land. It commonly occurs in formations that are very thick and extensive, and usually can be pumped from wells continuously, even during periods of drought or low rainfall. And, because ground water is insulated and protected below the surface of the earth, it is far less subject to contamination and pollution than the water in rivers and lakes.

Natural underground reservoirs (aquifers) have many great advantages:

- They are freely available for storing water without spending a cent for dam construction
- They have tremendous capacities and don't become clogged with silt and weeds as lakes and surface reservoirs do
- Aquifers are relatively inexpensive to tap
- They lose little or no water by evaporation
- They can supply water over very large areas without the necessity of building canals or pipelines
- If they are properly managed, their period of usefulness has no foreseeable time limit.

Although America's dams provide water for many uses, the ecological effects, especially for fish populations, have often been disastrous.

Dependability is one of the major benefits of using ground water as a source of supply. Droughts and dry spells that lower levels in streams and lakes seldom have any serious effect on aquifers. Even though natural replenishment through the soil is reduced or even halted during such periods, huge amounts of water are usually present in the ground water "bank", where they serve as a reserve to tide the well owner over until the rains come again.

SELECTING THE SITE

Although ground water can be found almost everywhere, locating an adequate supply for a particular purpose calls for specialized know-how. Because ground water is hidden from view, the help of an experienced water well contractor or ground water specialist may be needed to find the best place to drill a well. Sometimes, if a large water supply is needed, a careful study of the rocks and their water content may have to be made to show

the locations and depths of the most productive rock layers.

The specialist familiar with ground water first examines the land surface to visualize the hidden beds of rock or sand. This inspection, together with knowledge and experience, often allows on-the-spot recommendations to be made on where to construct an efficient water well. Sometimes it may be necessary to drill one or more test wells to find the water and to determine its quality and quantity, especially if a large amount is needed, say for a town or industry.

WATER TABLE AND ARTESIAN WELLS

Wells are commonly referred to as either "water table" or "artesian" wells. A water table well is one that taps the first water zone encountered during drilling. An artesian well is one that taps a rock bed containing water under pressure. Sometimes the pressure is great enough to cause the well to flow at the surface.

Generally speaking, the water table is a more or less continuous surface, below which the rocks or sediments are saturated with water. It tends to have a shape somewhat like that of the land surface itself, sloping downward from hilly areas toward low places. The water

Confined and Unconfined Aquifers

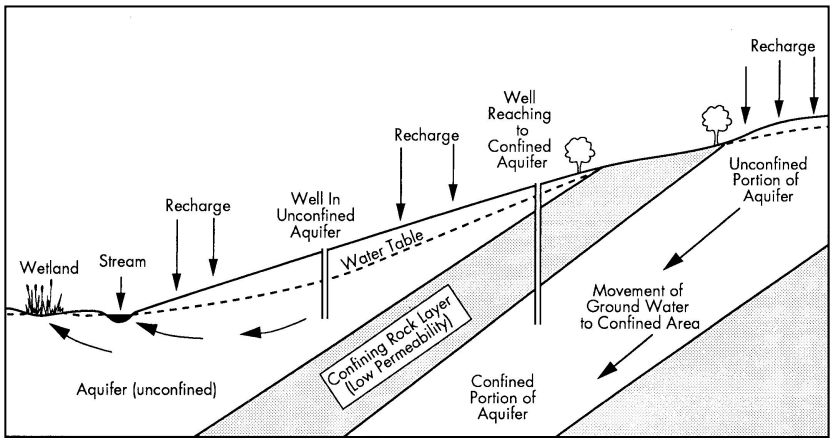


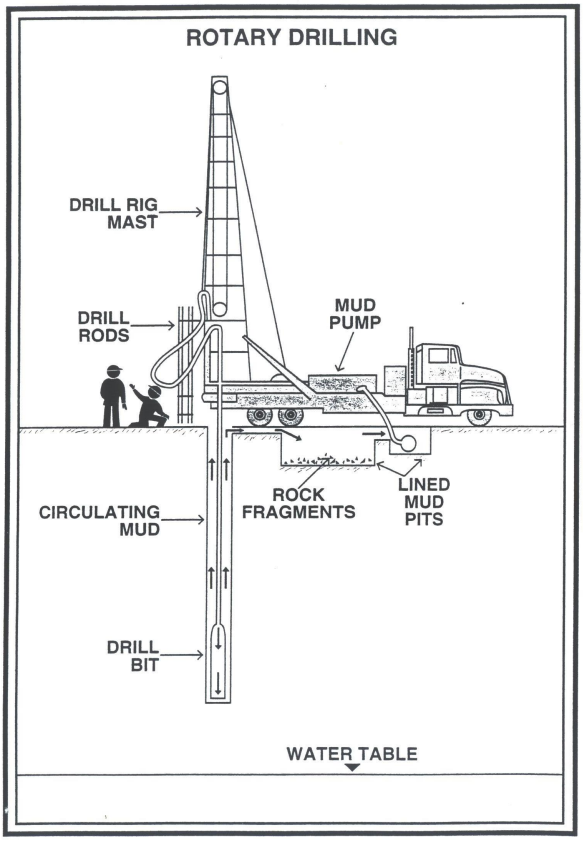
table is usually closest to the land surface in river valleys and at greater depths beneath hills. Many ponds and lakes may be thought of as land surface depressions in which the water table is exposed. Similarly, streams that flow all year long are like drainage ditches that receive water from seepage of ground water into the channel.

Some geologic formations with artesian water may be found only a few feet below the land surface; others are many hundreds or even thousands of feet below the ground. The water level in a true artesian well rises and falls as the barometric air pressure in the region changes. A test of whether or not a well is artesian is to record the changes in its water level to see if they occur with changes in atmospheric pressure.

A flowing well is always classified as artesian. In the U.S., some flowing wells produce many thousands of gallons per minute. A flowing well results when a well taps a water bearing formation where the pressure is great enough to force water up to the land surface. This is a special type of artesian well. Flowing wells are most common in valleys and along coastlines.

HOW A WELL IS CONSTRUCTED

Water wells are constructed by means of specially-designed machines or rigs that drill into the earth to encounter productive water-bearing formations. Some drilling machines work by lifting and dropping a long chisel-shaped tool which forms a hole by cutting up the rock or other earth materials. Another type of water well drill rotates a bit fixed to the lower end of a steel pipe called the drill pipe. The bit loosens and crushes the materials encountered as the hole is deepened. Special mud can be circulated to remove the pieces of rock broken up by the drill bit. The drilled hole is lined with steel or plastic pipe called well casing. The casing serves as a structural retainer to prevent caving of the hole and to shut out water of undesirable quality found in certain formations. In hard rock areas, the casing only needs to extend through the loose overlying materials and then be firmly sealed in the bedrock. If the well ends in a layer of sand and gravel, a well screen may be placed in the water bearing sand as an extension



of the casing. The well screen supports the loose formation and allows water to enter the well freely while at the same time keeping sand from coming to the well with the water. Perforated pipe is sometimes substituted for a well screen, but it is often not as effective.

The final step in completing a well is to install a proper pump and sterilize the entire installation. Pumps come in all sizes and types, and the well contractor can recommend the one best suited for the diameter, depth, and capacity of the well. Treatment equipment can also be installed to do everything from chlorinating the water to removing hardness, iron, or other substances that may be present in the water.

THE GROUND WATER CONTRACTOR

Drilling a modern water well is no job for amateurs, and only a professional ground water contractor is thoroughly familiar with all the new methods and equipment needed to bring in a good supply of ground water. Different kinds of wells call for different techniques, which means that a great deal of know how is involved in properly constructing and finishing a water well. The ground water contractor

must be a person of many talents, and is a water specialist, engineer, and craftsman all at the same time. His business success and reputation are built upon doing a good job for each customer.

Water well drilling is a major industry in the United States today. The construction of vitally needed water supply systems involves an estimated 8,000 contractors. The total value of household water wells installed in a typical year is close to 3 billion dollars.

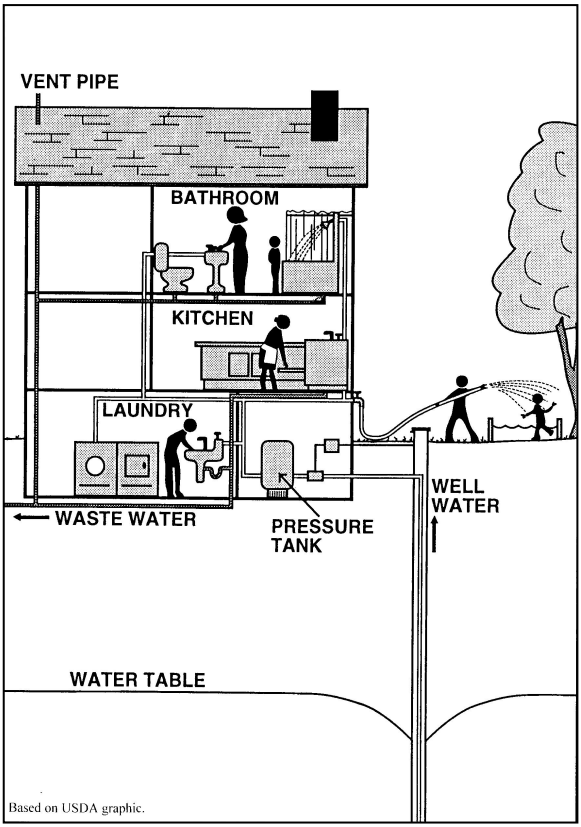
A good contractor enjoys a good reputation and is accustomed to working under the terms of a written contract. He operates up-to-date, well-maintained equipment and provides insurance protection for the property owner. He estimates the cost of the job step-by-step, including a breakdown of unit prices. When the job is completed, he provides a record of the rock strata penetrated by the well (a well log) a statement of work performed, and the materials used. In most cases, he'll be a member of the state and national associations of ground water contractors. This is evidence that he keeps abreast of all the new developments in his field.

PLENTY OF WATER FOR EVERY USE

The ease with which a water supply can be obtained from wells is one main reason why this resource should be given first consideration every time a new water supply is planned.

It is more than likely that ground water can be found on almost any tract of land. The amount available, whether a few gallons per minute or perhaps hundreds of gallons per minute, can be determined by test drilling and other scientific prospecting methods. Secondly, the cost of getting this water is almost always lower than the cost for any other kind of water supply. And finally, a privately (independently) owned well water system can free you completely from monthly utility bills, worries over municipal water shortages, and/or pollution of surface water supplies.

Today, ground water accounts for 35% of all the water used by municipalities in the United States and over 80% of the water used in rural areas for homes and livestock. It is a large source of



Home Water Use

supply for industries and is tapped very heavily for irrigation of crops in certain parts of the country. With the population of America increasing to 370 million by the year 2050, (another 70 million people), ground water will be of increasing importance in rural areas.

PROTECTING GROUND WATER RESERVES

The availability of adequate, clean water for the various uses of our complex and growing society is a necessity of ever-increasing importance.

Ground water is unpolluted and of excellent quality over large areas in its natural state. However, it can be contaminated by short-sighted methods of waste disposal or by land uses that convey chemicals to recharge areas.

Two of the dangers to avoid are over-pumping and pollution of underground waters. Local and State regulations have been established in many places controlling pumping and land use. For example, a prospective well owner may be asked to make a formal application for a permit to drill a well. If the new well is constructed properly and if it will not harm the ground water resource in any way, an approval is usually granted.

In recent years an increasing amount of attention has been given to preventing pollution of ground water. Modern planning requires careful disposal of all wastes to avoid putting contaminants in the ground, which would pollute the ground water. This is especially important in built-up areas. Many communities are now replacing old-fashioned waste water disposal units with modern systems and treatment plants.

Porous soil possesses the capacity to purify water. In fact, the physical, chemical, and biological processes that take place in the soil remove most of the harmful constituents of household waste water. The air in the pores of the soil above the water table, in what is called the zone of aeration, plays the major role. Intimate contact with the percolating waste water oxidizes some of the organic matter to harmless solids or gas. A high proportion of the harmful bacteria are killed and filtered out. Soil bacteria themselves aid in the purification process.

It is important to keep this in mind because even though isolated traces of contamination may be found in some shallow wells, this does not mean the entire underground water supply is permanently polluted. Rather, by removing the sources of contamination and relying upon the earth's natural filtering ability to do the job, there are very good assurances the ground water will be restored to its natural state, and thus to full usefulness as a source of good, potable water.

In some areas of critical water shortage special basins, pits, or wells have been constructed to return water underground that otherwise might have been lost into rivers or the sea. Industries

that pump ground water for cooling purposes, for example, may be required to place it back underground after it has been used in order to conserve the supply. On Long Island, New York, and in parts of southern California, ground water recharge installations of this type can return hundreds of millions of gallons to keep natural subsurface water reservoirs as full as possible.

This pamphlet has provided some basic information about wells and groundwater. The more that citizens and communities know about this precious resource, the more we will recognize its great economic and environmental value.

For More Extensive Information About:	**American Ground Water Trust Source**
Having a Water Well Drilled	Pamphlet #8 *When You Need a Water Well*
How Wells are Constructed	DVD: *"Water Well Basics"*
Wells and Ground Water	www.privatewell.com www.agwt.org

AMERICAN GROUND WATER TRUST

Independent Authority on Ground Water

The Trust - Working Everyday for you and for America:

- Protecting ground water resources for sustainable use
- Communicating the environmental and economic value of ground water
- Showcasing ground water science and technology solutions
- Increasing citizen, community and decision-maker awareness
- Facilitating stakeholder participation in water resource decisions

The American Ground Water Trust is a 501(c)(3) non-profit membership organization. Individual, corporate and organization annual memberships help support the Trust's ground water education programs. Visit our website to get information about Trust membership, the Trust's Ground Water Institute training programs for teachers, upcoming workshops & conferences and products available in our bookstore.

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